Conjectures and Refutations

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There is a commonly held misunderstanding about empirical epistemology, going back to Francis Bacon, that knowledge derives from observations rather than the other way around. This view implies that given empirical data they somehow determine an underlying theory which it is the business of the scientifically trained person to divine. It is analogous to the case of a typical intelligence test where an individual is confronted with a sequence of numbers and asked to continue the sequence. The underlying assumption being that the sequence somehow exhibits a pattern which is more or less manifest, and the more intelligent the individual the greater his or her ability to divine it. The problem is only, as every mathematician understands, that there is in fact an infinite number of different patterns that can fit a given finite set of data, only if you *a priori* are to understand that the pattern will be of a certain type that the problem becomes meaningful at the price of becoming less interesting. It is the same thing with scientific theories, there are in principle an infinite number of different explanatory theories that can fit the observations. Now if you decide that a theory will be of a certain type, i.e. coming equipped with a number of open parameters, you can by fiddling the parameters adjust to any data. A classical case is Ptolemoios theory of planetary movements using epicycles. By adding enough epicycles and tinkering with parameters, the theory can, albeit in cumbersome ways, accommodate itself to any number of celestial observations. The theory becomes in the words of Popper non-falsifiable.

Now the heliocentric view, as discovered and revived by Copernicus, constituted a radical departure from Ptolemois. The inspiration for it, Popper suspects, was not the careful study of astronomical data and thereby a case of a superior and more precise analysis, but instead it was based on neo-Platonic myths, in which the sun was seen as the divinity and hence its rightful place was thought to be in the center. The heliocentric assumption led to a simplification, but because of preserving the circular shape of the planetary orbits, Copernicus was not able to wholly dispense with epicycles to accommodate observational data and to allow predictions. As is well-known the Catholic church took strong exception to the heliocentric theory, but had no problems with it as a means of calculations. Thus they accepted it in an instrumental sense, but not in a real one.

Scientific theories seen merely as instrumental is a very fashionable modern assumption championed by Ernst Mach, who wanted to do away with any reference to say force. Such a modern and systemized approach can in its essentials be traced back to the idealist George Berkeley as Popper argues. That Popper is an obvious opponent of the notion of essentialism is hardly surprising, as he is opposed to any notion of definitive answers. But being against essentialism is not the same thing as being an instrumentalist as Popper is quick to point out. Instrumentalism is intellectually very appealing and it is of course harder for Popper to convincingly argue that he differs from the instrumentalists than from the essentialists starting with Aristotle. His key argument is that of making a distinction

between retrodiction and prediction. It does indeed make a difference whether evidence for a theory is prior or posteriori to its formulation. Given the data, it is far easier to tinker with an explanation in an ad hoc manner than to influence the results of any future experiments which the theory will have provoked. Any theory has unintended consequences, just as any technical invention has unintended properties (this is what drives evolution), and such unintended consequences need to mesh empirically with the outside world before we can (tentatively) accept the theory. A new theory is indeed far more striking when instead of just explaining old facts it suggests new, hitherto unexpected facts, which turn out not to be contradicted by future experiments. (One needs to write experiment here, as experience is not enough. There is far more to the world than our experience, an experiment is indeed designed to provoke hitherto unexperienced facts.). Popper argues that the instrumentalist point of view cannot satisfactorily account for this difference. Instrumentalists, according to him, are committed to already known phenomena. Furthermore he takes exception to their distinction between first hand observations as being the only real phenomenon, and all higher order observations mere formalities. In every observation there is an element of abstraction and theory, admittedly some observations are more theoretical than others, just as he notes, some theories are more conjectural than others. But even the most basic observations cannot wholly dispense with the theoretical. The disposition of a glass to break cannot be directly observed. In the same way replacing the notion of force as being ghostlike with acceleration does not dispense with the difficulty. In what way can we directly observe acceleration (or velocity for that matter)? To Popper theories are not just instruments in the sense of mathematical models, and the mathematician Yuri Manin may at least half-way endorse Popper when he speaks about theories as belonging to the aristocracy of mathematical models. A theory entails more than what is put into it. It has unintended consequences and points to new conceptions. I would say that Maxwells equations provide an example of a theory, while Navier-Stokes is just a mathematical model. The first is simple and daring and has something of the inevitable to it, while the latter strikes me as somewhat ad hoc. Mathematical models are fashioned out of the old and well-known and are subject more to the tinkering with parameters, such as the aforementioned yoga of epicycles of Ptolemois. In a sense theories are 'true' although one should be careful not to speak of ultimate theories, that would be essentialism.

The heliocentric view would predict parallax, i.e. that the fixed stars would show an apparent motion across the sky due to the movement of the earth along its orbit. That it did not exhibit this was correctly explained away by Copernicus, proposing that the stars were just too distant to allow us to detect it. On the other hand with the subsequent invention of the telescope a different kind of observation was made possible, observations which did not just concern the movement of point-like light objects, but revealed new features such a the exhibition of the phases of Venus. Still one might argue that the question of which moves around which is meaningless unless there is a fixed and conventional choice of reference. Indeed for a human observer it is far more convenient to think of the sun moving across the sky than the earth actually rotating. Newton, however, thought about space as being a fixed absolute entity and argued that the curved surface of water placed in a rotating bucket proved the absolute character of the rotating movement. Similarly he predicted that the shape of the Earth would be flattened at the poles, which

was subsequently confirmed through costly and painful expeditions after his death[1]. With Einstein the absolute character of space and time was once and for all abolished replaced by the notion of the equivalence between frames in uniform motion with respect to each other[2] The provocation for Einstein's theory of special relativity was of course the failure of the Michelson-Morley experiment. Ad hoc explanations in terms of length contractions were clearly in the instrumentalist spirit. They were proposed by Fitzgerald and Lorentz. The great French mathematician Poincaré (an instrumentalist if any[3]) did present more or less simultaneously with Einstein the elegant formalism eventually perfected by the mathematician Minkowski. But Einstein differed profoundly[4] from those as his theory was explanatory in spirit and thus opened up new ways of seeing and thinking. A scientific explanation, according to Popper, is not so much explaining the unknown by reducing it to the known, as putting the known into the context of the unknown. Scientific theories do not fit into preconceived schemata, as we already have been careful to point out.

Thus theory does not stem from observation, it stems from reasoning and speculation. Popper is in particular enamored with the Pre-Socratics, especially Xenophanes and Anaximander. The first because he more than anyone else prior to Socrates emphasized the vastness of our ignorance and hence the need for intellectual humility; the second for the daring of his cosmology for which experience supplied no guidance. Especially his idea of the Earth floating unsupported in the void of the universe, because there were no preferred direction of fall is particularly beautiful, as it did away with all kinds of infinite regresses of supports (Turtles all the way.).

In the speculative daring of a scientific theory lies its beauty and value. Hence even if a theory turns out to be false it can nevertheless turn out to be useful, either because it can be modified into a more correct one, or more generally and importantly some of its features may provide inspiration and actually work in different contexts. Popper was adamant in his criticism of Marxism and Freudianism, two favorite isms of the early part of the 20th century. What he criticized was their unfalsiability and hence avoidance of confronting reality. Freud had original and counter-intuitive ideas about how the psyche works, and those clearly had the 'feel' of scientific exploration, in fact Freud thought of himself in the tradition of Copernicus and Darwin. There is nothing wrong with the speculation of a Freud as long as speculation does not ossify as dogma. Original speculation is necessary, and of course any kind of intellectually daring speculation will have a kind of beauty. But unbridled speculation leads to hybris and becomes eventually arid. The imagination is at its most fertile when it encounters resistance. Freud is now completely discounted, except for a few diehards of a sectarian bent. This might be a bit of a pity because some of his

[1] A more direct exhibition of the rotating earth is of course Focault's pendulum.

[2] The original name for his theory was invariant theory, as he was concerned with the entities such as the velocity of light which were invariant. It is unlikely that this title would have caught the imagination of the general public in quite the same way as the 'sexier' title relativity theory did.

[3] This may be an oversimplification. According to Popper he was like Kant an absolute believer in Newton. On the other hand his attitude to non-euclidean geometry and its relevance to physics shows a definite instrumentalist attitude.

[4] I am indebted to the mathematician Armand Borel to point that out at a lecture at Ann Arbor in 1999.

ideas may be worth pursuing meaning that they should be tested and accordingly modified. The origin of ideas are of marginal importance if anything, it is the way they hold up to tests which in the long run matters.

It cannot be emphasized enough that the ideas of Popper are not new. Few ideas in philosophy actually are. Hume and Kant are the two main modern influences on Popper. To Hume he is indebted to the rejection of induction as overriding principle in scientific inquiry, the idea that we cannot derive universal laws from a finite number of observations. To Kant he owes the idea of testing, i.e. to distrust unbridled speculation. The whole treatise of Kant on the nature of pure thought is based on a problem that confronted the author. Kant a champion of the Enlightenment took as a premise that Newton's theory was right. He observed correctly that it could not be derived from observations, but then how were we able to know it? This provides the impetus for the problem of synthetic knowledge a priori. Kant who was a more than competent Newtonian did in his youth propose a suggestion for the creation of the Solar System, thus exhibiting a degree of mathematical and physical mastery which is rare among professional philosophers. He also noted that when speculation is unbridled you are easily led into silliness and contradiction. If you ponder questions such as whether there were a beginning of time you get into anomalies out of which you cannot extricate yourself by reason alone. His conclusion was that thought that is not empirically challenged dissipates into mere silliness (such as the grand theories of a Hegel). Of course the empiricism should not be taken too literally, as Baconists and instrumentalists are prone to do. What it amounts to is that there has to be some sort of connection, however, indirect and tenuous to the real world. However, once the absolute character of Newton's celestial theory is abandoned, the problem that initially motivated Kant is gone, and hence many of the things to which he had to pay such attention, turn out to be irrelevant. But nevertheless Kant contain very influential and fertile ideas, such as that we to some extent impose our own laws on nature, that the creation of science is in many ways similar to the creation of art. The same kind of intuition at play, although with art there is no falsiability, no real holding of account.

Ultimately, whether refutable or not, a theory has to be grounded in a problem, in order to be amenable to rational criticism. This holds for philosophical problems as well as scientific. If Newton's theory would have been flung at us with no reference to the problems it sought to address and solve (such as Kepler's law and Galileos mechanics) it would have been on the level of the book of Revelations. Kant was a determinist, although a reluctant one, as he was committed to Newtonian mechanics. His moral philosophy on the other hand has a definite indeterministic bent, Hume on the other hand was an idealist and an irrationalists, although by temperament it was harder to find someone saner and more measured. But as Popper explains, he and Berkeley were convinced that all knowledge should be reduced to sense-data, but Hume failed to do so, and hence out of intellectual integrity he was forced to assume idealism, which did not sit well with him. Likewise as he was committed to a Baconian scheme of acquiring knowledge at the same time as he was showing the inadequacy of induction he was forced to be an irrationalist. No wonder that he abandoned philosophical inquiry in his youth and turned to other pursuits. Even Schopenhauer had a rational approach to problems inherited from Kant. His mistake, according to Popper, was to assume that the limits of human reason coincided with the

limits of possible experience. A philosophical problem, Popper reminds us, may be given once and for all, but that does not hold for its suggested solutions.

Truth is of course central to Popper's (unending) quest. But what is it? Can we give a 'true' definition of truth, or at least 'true' criteria for truth? Poppers original attitude was meta-physical. Truth lies beyond that and hence should appropriately be spelled with a capital 'T'. Truth is objective, theories can be true without we not knowing that they are true. To base truth on criteria and connect it with belief necessarily makes it ultimately subjective. Truth is not the same thing as conviction however well justified. Truth is not mere consistency, which is a tempted attitude taken by an axiomatic approach[5]. Nor has it to do with usefulness which is the pragmatic approach championed by William James. Truth is correspondence with the facts, which of course only strikes you as a trivial reformulation, but of course one which is somehow local and modest and relevant to a testing situation. But Popper claims, somewhat surprisingly to me, that with Tarski's definition of truth, there is no longer any reason to be ashamed of it. Tarski has taken down Truth from the metaphysical realm and made into into an ordinary concept with which we may deal in a a down-to-earth way. I remain doubtful. It seems to me that in practice criteria for defining what is entailed by correspondence to the facts are not set out from the start but are emerging in each situation of conflict. Two parties that quarrel about what is true will have to find some common ground. i.e. find a level congenial to both in which a suggested refutation is framed. This ties in with the notion of democracy to which we will return further on.

As to the asymptotic approach to truth Popper points out that it is very important that each new theory not only corrects the mistakes of its predecessors but that it predicts new phenomena which we can verify. If this would not be the case, we would simply think of the succession of theories as an interminable process of saving appearances. In fact this is the stratagem of Ptolemois, by adding more and more epicycles we can explain away mistakes of less elaborate theories. But of course Copernicus predicted new phenomena, such as the phases of Venus and Mercury, which, as we have already noted, with the invention of the telescope became observable. There is a true distinction between theories that merely adhere to previous observations and those who suggest new observations. It is not just a matter of historical accident, which one comes first. Because new theories make us look differently at the world, and hence to make new kinds of observations, we otherwise would never have thought of making.

We want the truth, but not just the truth. We crave interesting truths that pertain to problems that are close to our concern, problems we find interesting and compelling, and which have fertile consequences and lots of ramifications.

Popper has often been seen as one of the logical positivists of the Vienna Circle. In particular he has been seen close to Rudolf Carnap, although he has always been careful to distance himself from the association. In fact Carnap claimed in exasperation that while the distance between him and Popper was small, the distance between Popper and him is allegedly enormous. What Popper objected to in the project of the Vienna Circle

[5] The Peano Axioms may very well be consistent, yet we cannot prove its consistency using them. Thus we can add the false statement that they are inconsistent, yet obtain a consistent system of axioms (provided of course that the Peano Axioms are consistent.

was the ambition to make a demarcation between the meaningful and the meaningless, in particular to rid science of all vestiges of metaphysics. The road to such a goal was through a formal language whose very syntax would make meaningless and metaphysical statements impossible. It was to involve a clearly defined vocabulary, every word used had to have a meaning, then it should involve an exacting standard of syntax which should only allow proper combinations of words, and finally and most importantly, it should be hierarchially built, based on atomic sentences, each of which had a direct empirical content. Not only did Popper claim that the ambition was impossible to fulfill, but that it was based on a pseudo-problem. Furthermore he resented the implication, heralded by Wittgenstein, that all philosophical problems were at their root linguistic problems. Formal languages have indeed been devised in great profusion, but their scopes have been limited and their purposes focused on mechanical implementations on computers. There exists no formal language that is powerful enough to encompass all of science, in fact not even of mathematics.

Science is not just physical science although from an ontological point of view this is the most basic and conceptually most daringly formulated, and in no other scientific endeavor are theories so elegant and comprehensive and by necessity so counter-intuitive. On the other extreme we have the social world and politics, on which Popper has much to say. Popper is a strong proponent of democracy, but this is not based on such notions as the will of the people and focused on elections as a way of having the former articulated. The people is an abstraction which can be used to a variety of purposes and in whose name the most atrocious deeds can be justified. Public opinion is anonymous and hence not accountable. The model for democracy is scientific dispute, the process with which a tentative approach to truth can be achieved. It involves a modest approach where the fact of our immense ignorance is never to be lost and in which we are willing to learn from our opponents. A dispute may not lead to a definite resolution, all our knowledge is tentative and provisional as Popper repeatedly stresses, but it allows different points of view to come to the fore, and an individual should not be judged as much as the arguments he or she proposes. The question put by Plato of whom should rule is an ill-posed one, according to Popper, the right question is not so much of getting wise and competent rulers but how to get rid of foolish and incompetent ones without bloodshed. Democracy is far from perfect in the words of Churchill, but the alternatives are even worse. In political life we should not strive for the perfect but for damage control, to ensure that the worst does not happen. As to governmental intervention Popper is somewhat of a minimalist. He flirted briefly with communism in his youth and remained throughout his life a kind of social democrat committed to the welfare state. But he was adamant that the responsibility of the state should be limited to the removal of misery and not to include the task to ensure personal happiness. Hardly surprisingly Popper was in favor of a market economy. He criticized Marx sympathetically, lauding his moral indignation and finding his exhortion that philosophers should not be content with just explaining the world but should try to change it as well very sympathetic; but took exception to his grand view of history and the notion of inevitable historical forces. Such entities do not exist, we as individuals are always responsible. However, this does not rule out the possibility of short-term predictions. If it did not only would politics be impossible but no individual would be able to plan ahead

in the social world. Economics may be the social science that come closest to the natural sciences, especially in the way it lends itself to formalization, and some of its predictions you can only ignore at your peril. Reform should never be radical, because large experiments involving social life are dangerous, instead they should be piecemeal and conducted within the framework of a tradition. In that regard he was a follower of Edmund Burke. The most valuable of all the traditions was the one we had inherited from the Greek, namely the tradition of the rational inquiry and the scientific method of trial and error and critical assessment. Rationalism can never be rationally justified, it is in many ways a leap of faith. To us it is given as a tradition. You can never convince someone by argument to listen to argument. The willingness to engage in discussion must stem deeper, namely from a loving tradition. It is this emphasis on tradition that makes radical social change so dangerous, according to Popper. Along with sweeping changes comes a destruction of tradition, whose values motivated the change in the first place. With the destruction of tradition there is nothing left to guide the revolution, and it leaves you with the task to start all over again[6].

The most interesting and the most pressing problems of the Social sciences is to explain unwanted and hence unintended consequences of social reform, whether out of pure scientific curiosity or for us to be prepared for the unexpected. Most of the adverse features of society are not due to conspiracy, i.e. intention, but are hapless consequences of well-meaning intentions. Another interesting problem of social science is the emergence and perpetuation of traditions, the importance of which we have already emphasized. In many ways traditions too involve many unintended consequences, but all such need not be unwanted. Traditions are important as they relieve an individual, as well as a society to start a fresh every time. In science you need to accept the tradition and immerse yourself in it, otherwise you will get nowhere. The starting point are the problems to which tradition has led and which occupies everyone. The advice to a young scientist to start out is to find out where there are especially ferocious disagreement and listen to both sides. The case of science may be somewhat extreme, in the case of philosophy and the arts, tradition is of course very important and inescapable, yet there is a possibility to return to basics as neither philosophy nor the arts have such an unequivocal sense of progress and accumulation. Progress in science has a specific meaning of metaphysical nature, namely it involves closer and closer approximations to truth. This should not be confused with social progress to which science often has been seen as a contributor. There is no testable criteria for the progress of society as there is in science. Of course Popper admits that we can put up some minimal ones, such as the freedom of basic wants, leading to a decent society, but beyond that the notion of progress does not make sense. Recall that Popper believes the responsibility, maybe even the main responsibility of the State to be the abolition of misery not the creation of happiness, that pursuit is up to the individual.

Popper is an optimist. This is clearly an expression of temperament and personality than a scientific conclusion. Obviously you can find striking arguments both for an op-

[6] The Chinese experiment headed by Mao consisted precisely in destroying old traditions. Hence the role of the vanguard being relegated to the very young. The destruction was not total, allowing its Society to bounce back with a vengeance, at least from an economic point of view.

timistic as well as a pessimistic attitude towards the future. Popper may be contrasted against the pessimist Russell who claimed that the problem of mankind was that it was too clever for its own good and wicked. This special mixture of cleverness and wickedness made for real trouble. Poppers attitude is the opposite. We are not really wicked, we are good. Maybe a little bit too good for own good. And in addition we are a bit stupid. It is this mixture of goodness and stupidity that lies at the root of our troubles. More people are probably killed because of righteous stupidity rather than wickedness.

He claims that life has never been so good in the history of mankind as it is now under the free governments of the West. No other society has been able to mitigate the misery of its subjects more successfully and completely. The basis of Civilization is the Greek discovery that one can fight with words rather than swords[7].

But in one respect Popper is not an optimist. He does not believe in the doctrine that truth is manifest, instead truth is very hard to come by. Truth is not an inevitable consequence of observation, it is the result of guessing and intuition consistently frustrated. Truth as manifest has had many good consequences. The general spread of education being one of them, the belief that everyone is able to get to truth without instruction from the elect. The Greeks, according to Popper, had a different attitude to truth, a more critical one. So although Poppers heart and instincts are with the optimistic view of the attainment of truth, his reason compels him to side with the wise pessimists who take a dim view on the erosion of authority and the decline of tradition. Much of 20th century history has illustrated the appropriateness of their apprehensions. But wisdom is not the same as being right. It is not necessary to draw authoritarian conclusions from the fact that truth is hard to come by. In fact the essence of Popper's philosophy of science is a grand attempt to show that. By subjecting every statement to the perils of refutation using criteria everyone involved can ultimately agree on, anyone who claims to have the authority to proclaim the truth cannot do so unopposed.

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[7] This of course plays very well with Poppers evolutionary approach to the acquisition of knowledge. The lowly amoeba has to risk its life as a result of inevitable error in its unavoidable trials; while a more advanced organism can represent the struggle mentally and have his pet ideas die in his stead.